

PROPELLER SHAFT ARRANGEMENT, PROPELLER ARRANGEMENT, ADAPTIVE ARRANGEMENT AND PROPULSION ARRANGEMENT

DESCRIPTION

Cross-Reference To Related Applications:

[Para 1] The present application is a continuation patent application of International Application No. PCT/SE03/00335 filed 27 February 2003 which was published in English pursuant to Article 21(2) of the Patent Cooperation Treaty, and which claims priority to Swedish Application No. 0200581-7 filed 27 February 2002. Said applications are expressly incorporated herein by reference in their entireties.

TECHNICAL FIELD:

[Para 2] The present invention relates to a propeller shaft adapted to be connected to the output shaft of a drive motor, the propeller shaft having a portion provided with splines in order to permit a rotationally fixed connection to corresponding splines inside the hub of a propeller.

[Para 3] The invention also relates to a propeller including a hub with propeller blades secured to the hub, the hub being provided with an axial through-opening in which splines are arranged in order to permit a rotationally fixed connection between the propeller and a propeller shaft with corresponding splines.

[Para 4] The invention additionally relates to a propeller system including at least one propeller connected in a rotationally fixed manner to a propeller shaft, the propeller shaft having a portion provided with splines which cooperate with corresponding splines inside the hub of the propeller in order to obtain the rotationally fixed connection.

[Para 5] Still further, the invention relates to an adapter that enables a propeller system as described hereinabove regarding a propeller connected in a rotationally fixed manner to a propeller shaft by way of cooperating splines.

BACKGROUND OF INVENTION:

[Para 6] Propellers of the abovementioned type, for example on boats, are driven by a drive motor. The torque delivered by the drive motor is transmitted to the propeller via a drive shaft leading from the motor, a transmission mechanism and a propeller shaft. Since the propeller is designed with a through-opening in the hub thereof, with splines arranged in the through-opening, and the propeller shaft is designed with corresponding splines, a rotationally fixed connection is obtained, when the two (propeller and propeller shaft) are joined together, so that the torque delivered by the drive motor is transmitted to the propeller.

[Para 7] When the propeller of a boat is caused to rotate with the aid of the drive motor, the propeller generates a compressive force which drives the boat forward or backward depending on the direction of rotation of the propeller. The compressive force gives rise to a reaction force which is transmitted to the propeller shaft via the propeller hub. The propeller shaft is therefore provided with a flange against which the hub bears in order to take up the compressive force when the propeller drives the boat forward, and an end nut against which the hub bears in order to take up the compressive force when the propeller drives the boat backward.

[Para 8] A problem with the abovementioned type of spline connection between the propeller hub and the propeller shaft is, however, that only the torque delivered by the drive motor can be transmitted via the spline connection. Consequently, the resulting compressive force is transmitted completely via the flange or end nut, which means that these have to be given a relatively robust and therefore bulky construction, particularly in the case of high-power motors. Another problem is that the propeller hub has to be made particularly robust, and therefore bulky, at those parts which are intended to bear against the flange or end nut. This is particularly problematic in what are

known as twin-screw arrangements, that is to say two propellers rotating counter to one another on the same longitudinal geometric axis, where one propeller is connected to a propeller shaft extending through a bore in the second propeller's propeller shaft, and where a large number of components therefore have to be accommodated within a very limited space.

SUMMARY OF THE INVENTION:

[Para 9] It is an objective of the present invention to provide a propeller shaft adapted to be connected to the output shaft of a drive motor, where the rotationally fixed connection between propeller and propeller shaft is arranged to at least partially take up the compressive force which is transmitted to the propeller shaft, via the propeller hub of the propeller.

[Para 10] The invention thus relates to a propeller shaft adapted to be connected to the output shaft of a drive motor, the propeller shaft having a portion provided with splines in order to permit a rotationally fixed connection with corresponding splines inside the hub of a propeller. The splines on the propeller shaft are in this case helical, with a predetermined oblique angle, and the axial compressive forces which are generated by the propeller are at least partially taken up by the splines. This means that the axial limit stops, namely the flange and the end nut, can have a simpler design.

[Para 11] A further objective of the present invention is to adapt the oblique angle so that the resultant between the tangential force component of the torque delivered by the drive motor and the propelling compressive force is taken up in a direction substantially at right angles to the splines. This means that the dimensions of the axial limit stops, namely the flange and the end nut, can be made smaller, and that the propeller shaft can have the optimum strength.

[Para 12] By virtue of the fact that the direction of the helical shape of the splines along the circumferential surface of the propeller shaft (from the rear as viewed in the direction of travel) is chosen or arranged to be counterclockwise. In this manner, with one propeller rotating

counterclockwise and conversely one propeller rotating clockwise, the stresses on the axial limit stops, namely the flange and the end nut, are reduced. Consequently, the stresses on the support surfaces of the propeller hub bearing against the limit stops are also reduced.

[Para 13] It is a further object of the present invention to make available a propeller comprising a hub with propeller blades secured to the hub, which hub is provided with an axial through-opening in which splines are arranged in order to permit a rotationally fixed connection between the propeller and a propeller shaft with corresponding splines. The rotationally fixed connection is arranged to at least partially take up the compressive force which is transmitted to the propeller shaft, via the propeller hub, of the propeller.

[Para 14] Thus, the invention also relates to a propeller comprising a hub with propeller blades secured to the hub, which hub is provided with an axial through-opening in which splines are arranged in order to permit a rotationally fixed connection between the propeller and a propeller shaft with corresponding splines. The splines in the hub are in this case helical with a predetermined oblique angle, and the axial compressive forces which are generated by the propeller are at least partially taken up by the splines. This means that the support surfaces which are arranged on the hub of the propeller, and which are intended to bear against the flange and the end nut, can have a simpler design.

[Para 15] According to a preferred embodiment of the propeller according to the invention, the oblique angle is adapted such that the resultant between the tangential force component of the torque delivered by the drive motor and the propelling axial compressive force is taken up in a direction substantially at right angles to the splines. This means that the size of the support surfaces on the hub of the propeller can be reduced and that the hub can have the optimum strength.

[Para 16] By virtue of the fact that the direction of the helical shape of the splines in the propeller hub (from the rear as viewed in the direction of travel) is counterclockwise, with one propeller intended to rotate counterclockwise during travel in the direction of travel and conversely one propeller rotating

clockwise, induced stresses on the axial limit stops, namely the flange and the end nut, are reduced (compared to conventionally configured arrangements) and, consequently, the stresses on the support surfaces of the propeller hub that bear against the limit stops are also reduced.

[Para 17] It is a further object of the present invention to make available a propeller system comprising (including, but not necessarily limited to) at least one propeller connected in a rotationally fixed manner to a propeller shaft, the propeller shaft having a portion provided with splines which cooperate with corresponding splines inside the hub of the propeller in order to obtain the rotationally fixed connection.

[Para 18] The rotationally fixed connection is arranged to at least partially take up the compressive force which is transmitted to the propeller shaft, via the propeller hub, of the propeller.

[Para 19] It is a further object of the present invention to make available an adapter to be included in a propeller system having a propeller coupled via the adapter in a rotationally fixed manner to a propeller shaft wherein the propeller shaft has at least a portion provided with splines which cooperate with corresponding splines inside a hub portion of the adapter in order to obtain the rotationally fixed connection. The splines on at least the propeller shaft are arranged at an oblique angle with respect to a longitudinal axis of the propeller shaft, and in a preferred embodiment are helically arranged.

[Para 20] Thus, the invention relates to a propulsion system comprising a propeller connected in a rotationally fixed manner to a propeller shaft, the propeller shaft having a portion provided with obliquely oriented splines which cooperate with corresponding splines inside the hub of the propeller, or a suitably arranged adapter, in order to obtain the rotationally fixed connection. Preferably, the splines on at least the propeller shaft are of helical configuration.

[Para 21] According to a preferred embodiment of the present invention, a first propeller is connected in a rotationally fixed manner to an outer propeller shaft. A second propeller is connected in a rotationally fixed manner to an inner propeller shaft extending through the outer propeller shaft. The

propeller shafts are drivably connected to a drive motor. This creates the conditions for a higher degree of overall efficiency of the propeller system.

[Para 22] In one embodiment, the propeller(s) and shaft(s) are arranged behind the driving lower unit in a "pushing" configuration. In an alternative embodiment, the propeller(s) and shaft(s) are arranged ahead of the driving lower unit in a "pulling" configuration.

[Para 23] Further preferred embodiments and advantages of the invention will become evident from the attached patent claims and from the description given below.

BRIEF DESCRIPTION OF THE DRAWINGS:

[Para 24] The invention will be described below on the basis of preferred illustrative embodiments and with reference to the accompanying Figs., in which:

[Para 25] Fig. 1 is a diagrammatic representation of a drive unit configured according to the present invention attached to the stern of a boat, and with the propeller's arranged in a "pushing" configuration;

[Para 26] Fig. 2 is a diagrammatic side view, shown partly in cross section and partly in cutaway, of a pair of propeller shafts arranged for counter rotation, each with splines that are helical, with a predetermined oblique angle;

[Para 27] Fig. 3 is a diagrammatic side view, shown partly in cross section and partly in cutaway, of a pair of propellers arranged for counter rotation, each having splines in the through-opening of the respective hub, which splines are helical, with a predetermined oblique angle;

[Para 28] Fig. 4 is a diagrammatic side view, shown partly in cross section and partly in cutaway, of a pair of propellers arranged for counter rotation, together with respective adapters associated with each of the propellers for affecting the association of the propellers with propeller shafts adapted as depicted in Fig. 2; and

[Para 29] Fig. 5 is a diagrammatic representation, shown partly in cross section, of a drive unit configured according to the present invention attached to the stern of a boat with the propeller's arranged in a "pulling" configuration.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT(S):

[Para 30] Figure 1 is a diagrammatic representation, taken partly in cross section, of a drive unit 1 for boats with an inboard motor 2 and with a boat propeller unit 4 attached to the stern 3 of the boat. The boat propeller unit 4 includes a shield 5 which is screwed to the stern 3, and in which a propeller rig 6 is articulated in order to permit pivoting of the rig 6 on the one hand about a vertical shaft for steering the boat, and on the other hand about a horizontal shaft for trimming and opening the propeller rig 6.

[Para 31] The torque delivered by the drive motor 2 is transmitted to a first propeller 7 and to a second propeller 8 via a horizontal drive shaft 11 which is mounted in the shield 5 and which is connected in a rotationally fixed manner to the flywheel 9 of the motor and to the drive joints 10 of the propeller rig 6.

[Para 32] Figure 1 also shows how the abovementioned drive joints 10 are connected in a rotationally fixed manner to an upper angle switch 12. The upper angle switch 12 is arranged in the propeller rig 6 and is connected in a rotationally fixed manner, by way of a vertical drive shaft 13, to a lower angle switch 14 for driving two substantially horizontal propeller shafts, namely an outer one 15 and an inner one 16, with which the first propeller 7 and the second propeller 8 are connected in a rotationally fixed manner.

[Para 33] Figure 2 shows, partially in cutaway and partially in cross section, an outer propeller shaft 15, and an inner propeller shaft 16 extending through the latter. The outer propeller shaft 15 is provided with a flange 17 against which a propeller hub positioned on the shaft 15 is intended to bear in order to take up some of the compressive force F_R which arises when the propeller is driving a boat forward. When the propeller rotates in the opposite direction, that is to say to drive the boat in reverse, the compressive force F_R is partially

taken up instead by an end nut 18 arranged at the end portion of the propeller shaft 15.

[Para 34] By providing the propeller shaft 15 with splines 19 which are formed at the propeller shaft 15 with a predetermined oblique angle α , defined as the angle between the splines 19 and the longitudinal direction or axis of the propeller shaft 15, it is possible to transmit the tangential force component F_T of the torque delivered by the drive motor 2 and also the reaction force generated by the compressive force F_R of the propeller. The oblique angle α is determined after calculating the expected tangential force component F_T and compressive force F_R so that the force F_S acting on the splines 19 is taken up substantially at right angles to these. In the example shown in Figure 2, the splines 19 are shown for a propeller 7 rotating counterclockwise, as viewed from the rear in the direction of travel. This means that the flange 17 and the end nut 18 can have a simpler design and that the propeller shaft 15 can be made smaller while retaining its strength.

[Para 35] The inner propeller shaft 16 is also provided with splines 20 which are formed in the propeller shaft 16 with a predetermined oblique angle β , defined as the angle between the splines 20 and the longitudinal direction or axis of the propeller shaft 16. The difference is that the splines 20 are turned (as threads on a bolt or screw) in the opposite direction in relation to the above-described splines 19 because, in the example represented in Figure 2, they are shown for a propeller 8 rotating clockwise, viewed from the rear in the direction of travel. The oblique angle is chosen in the same way as described above so that the force acting on the splines 20 is taken up substantially at right angles to the splines 20. This means that the flange 21 and the end nut 22 can have a simpler design and that the propeller shaft 16 can be made smaller, which is particularly advantageous as it extends through the outer propeller shaft 15.

[Para 36] The oblique angles α and β are determined taking into consideration the torque delivered by the drive motor 2, preferably at a motor speed corresponding to an expected cruising speed, and transmitted to each of the propellers 7, 8. Moreover, the configuration of the propellers 7, 8, for

example their blade areas, blade pitch and direction of rotation, would be taken into consideration in the determination. By virtue of the fact that the direction of the helical shape of the splines 19,20 along the propeller shafts 15,16, from the rear as viewed in the direction of travel, is chosen counterclockwise, with one propeller 7 rotating counterclockwise and conversely one propeller 8 rotating clockwise, it is possible to reduce the stresses on the axial limit stops 17,18, 21,22 and, consequently, to also reduce the stresses on those support surfaces (not shown) of the hub 23,26 of the propellers 7,8 which bear against the limit stops.

[Para 37] There follows an example of the calculation of the oblique angles α , β for a typical diesel motor. In the example, a diesel motor delivers a torque of 560 Nm at cruising speed. With a total transmission of 1:1.78 between the output drive shaft 11 of the motor 2 and the propeller shafts 15, 16, the propeller shaft torque is 996 Nm, which, divided between the two propeller shafts 15, 16, gives 498 Nm per shaft. The splines 19 of the outer propeller shaft 15 are further assumed to be arranged on the radius 24 mm, which gives the tangential force component $F_T = 20750$ N. The splines of the inner propeller shaft 16 are assumed to be arranged on the radius 13.5 mm, which gives the tangential force component $F_T = 36889$ N. Finally, the propellers 7, 8 are assumed to give approximately 5500 N in axial compressive force F_R at the cruising speed. To ensure that the force F_S will act at right angles to the splines 19, 20 of the two propeller shafts 15, 16, the oblique angle α for the outer propeller shaft 15 must therefore be $\arctan(5500/20750) = 14.8$ degrees, and the oblique angle β for the inner propeller shaft 16 must therefore be $\arctan(5500/36889) = 8.5$ degrees.

[Para 38] Figure 3 shows the propellers 7, 8, partly in cutaway and partly in cross section. For the sake of clarity, only the propeller 7 is described in detail, because the design of the propeller 8 is principally the same. Extending through the hub 23 of the propeller 7 there is a through-opening 24 in which splines 25 are formed with the same oblique angle α as on the propeller shaft 15 in order to permit coupling of the two, with a rotationally fixed connection being obtained for transmitting the torque delivered by the drive motor. The

oblique angle α is defined herein as the angle between the splines 25 and the axis of symmetry of the opening 24.

[Para 39] The propeller 8 is also designed with a hub 26, through which there extends a through-opening 27. Splines 28 with the oblique angle β are formed in the through-opening 27.

[Para 40] Figure 4 shows propellers 40, 41, partly in cutaway and partly in cross section, together with propeller adapters 30, 31. For the sake of clarity, only the propeller 40 and the associated adapter 30 are described in detail, because the design of the propeller 41 and its associated adapter 31 are principally the same. In this embodiment of the invention, the propellers 40, 41 are of traditional design wherein splines (or spline-receiving grooves, as the case may be) are oriented substantially parallel to a longitudinal axis of the propellers 40, 41. By way of the adapters 30, 31, propellers 40, 41, which are of conventional design, are made compatible to specially configured propeller shafts 15, 16 as described hereinabove.

[Para 41] Extending through a hub 33 of the propeller adapter 30 is a through-opening 34 in which splines 35 (or spline receivers 35, as the case may be) are formed with the same oblique angle α as the spline configuration on the propeller shaft 15. This corresponding configuration between the two spline arrangements permits coupling of the adapter 30 to the propeller shaft, with a rotationally fixed connection being obtained for transmitting the torque delivered by the drive motor. The oblique angle α is defined here as the angle between the splines 35 and the axis of symmetry of the opening 34. In the illustrated embodiment, the exterior of the adapter 30 is provided with splines conventionally arranged for mating engagement with receiving grooves in a traditionally configured propeller. By conventional design, it is meant that this spline arrangement between the adapter 30 and the associated propeller shaft is oriented substantially parallel to a longitudinal axis of the propeller 40 and shaft.

[Para 42] The propeller adapter 31 is also designed with a hub 36, through which extends a through-opening 37. Splines 38 with the oblique angle β are formed in the through-opening 37. As described above, splines of

conventional configuration are provided on an exterior surface of the adapter 31 for mating engagement with a similarly configured propeller hub.

[Para 43] The invention is not limited to the embodiments shown in the drawings and described above, and instead it can be freely varied while remaining within the scope of the patented claims. For example, embodiments of the present invention contemplate that the boat propeller unit can be equipped with a single propeller shaft, as well as a single associated propeller and adapter in corresponding configurations. Each case, that is individually considering a single propeller, a single propeller shaft and/or a single adapter having obliquely oriented splines in association therewith, is considered to constitute a protectable aspect of the present invention.

[Para 44] It should be further appreciated that splined connections have been described and claimed with respect to the presently disclosed invention(s). As will be appreciated by those persons skilled in the art, such splined connections are configured to prevent relative rotation between the so-connected components, and may take the form, among others, of abutting raised ridges, tabs, flanges and the like. Such splined connections may also assume a tongue-in-groove type configuration wherein one member of the connection comprises a projection and the corresponding member comprises a receiver for that projection. In this case, either the tongue or the groove may constitute the spline. What should be appreciated as being at least one objective with regard to the presently disclosed invention(s) is that these "splined" connective members are at least partially obliquely oriented with respect to a long axis of the propeller and shaft configuration with which they are, or will be related. It is because of this oblique orientation that forces are able to be taken up therein, thereby at least partially relieving the force or stress that would have been traditionally experienced on a conventionally configured receiving shoulder or end-nut from the propulsive force generated by a rotating propeller.

[Para 45] Still further, as shown in Fig. 1, the propellers 7, 8 are in a trailing position to the power unit thereby forming a propulsion system oriented in a "pushing" configuration. With respect to the present invention, it is also

contemplated that the propellers may be arranged in a leading position with respect to the power unit, thereby forming a pulling configuration as shown in Fig. 5. Therein, the drive unit 1a of an inboard motor 2a is shown mounted in the stern 3a of a boat and connected to a boat propeller unit 4a. The two counter-rotating propellers 7a, 8a are shown in a leading or "pulling" configuration generally pointing in the direction of travel of the carrying boat. Such a pulling configuration is described in greater detail in International Patent Application PCT/SE01/00193, published as WO 01/56876 and designating the United States, together with the corresponding US Application No. 182667 filed 8 November 2002, both of which are hereby expressly incorporated by reference, in their entireties for purposes of disclosure in the present application.

